US009074751B2

(12) **United States Patent**
Son et al.

(10) **Patent No.: US 9,074,751 B2**
(45) **Date of Patent: Jul. 7, 2015**

(54) **LIGHTING APPARATUS**

(75) Inventors: **Won-Kuk Son**, Ansan-si (KR); **Yevgeni Aliyev**, Ansan-si (KR); **Osmonalieva Gulmira**, Ansan-si (KR)

(73) Assignee: **Seoul Semiconductor Co., Ltd.**, Ansan-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 861 days.

(21) Appl. No.: **12/487,154**

(22) Filed: **Jun. 18, 2009**

(65) **Prior Publication Data**

US 2009/0316383 A1 Dec. 24, 2009

(30) **Foreign Application Priority Data**

Jun. 20, 2008 (KR) 10-2008-0058526
Jun. 30, 2008 (KR) 10-2008-0062668

(51) **Int. Cl.**

F21V 23/02	(2006.01)
F21V 9/16	(2006.01)
F21V 9/10	(2006.01)
F21V 14/00	(2006.01)
F21Y 101/02	(2006.01)
F21V 7/00	(2006.01)
F21Y 103/00	(2006.01)

(52) **U.S. Cl.**

CPC ... ***F21V 9/16*** (2013.01); ***F21V 9/10*** (2013.01); ***F21V 14/006*** (2013.01); *F21Y 2101/02* (2013.01); *F21V 7/0008* (2013.01); *F21V 7/005* (2013.01); *F21Y 2103/003* (2013.01)

(58) **Field of Classification Search**

CPC F21V 14/006; F21V 7/0008; F21V 7/005; F21V 9/10; F21V 9/16
USPC 362/84, 260, 800, 231, 296.01
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,007,365	A *	2/1977	Stempfle et al.	362/283
6,252,254	B1 *	6/2001	Soules et al.	257/89
7,156,539	B2 *	1/2007	Cronk	362/297
7,638,780	B2 *	12/2009	Kilburn et al.	250/492.1
7,837,348	B2 *	11/2010	Narendran et al.	362/231
7,942,556	B2 *	5/2011	Harbers et al.	362/294
2007/0058357	A1 *	3/2007	Yamaguchi et al.	362/84
2008/0089085	A1 *	4/2008	Popelek	362/514
2008/0158856	A1 *	7/2008	Shen	362/84
2009/0103293	A1 *	4/2009	Harbers et al.	362/231

FOREIGN PATENT DOCUMENTS

KR	199826951	7/1998
KR	1020060010368	2/2006
KR	100713226	5/2007

* cited by examiner

Primary Examiner — Anh Mai
Assistant Examiner — Jessica M Apenteng
(74) *Attorney, Agent, or Firm* — H.C. Park & Associates, PLC

(57) **ABSTRACT**

A lighting apparatus includes a light reflector, a light emitting diode (LED) and a light-changing film. The light reflector has a concave surface. The LED is disposed under the concave surface of the light reflector to provide the concave surface with light. The light-changing film converts a first light generated by the LED into a second light. For example, the light-changing film may be a fluorescent film receiving the first light and emitting the second light with increased wavelength. The LED and the light-changing film are spaced apart from each other to minimize discoloration of the light-changing film.

23 Claims, 7 Drawing Sheets

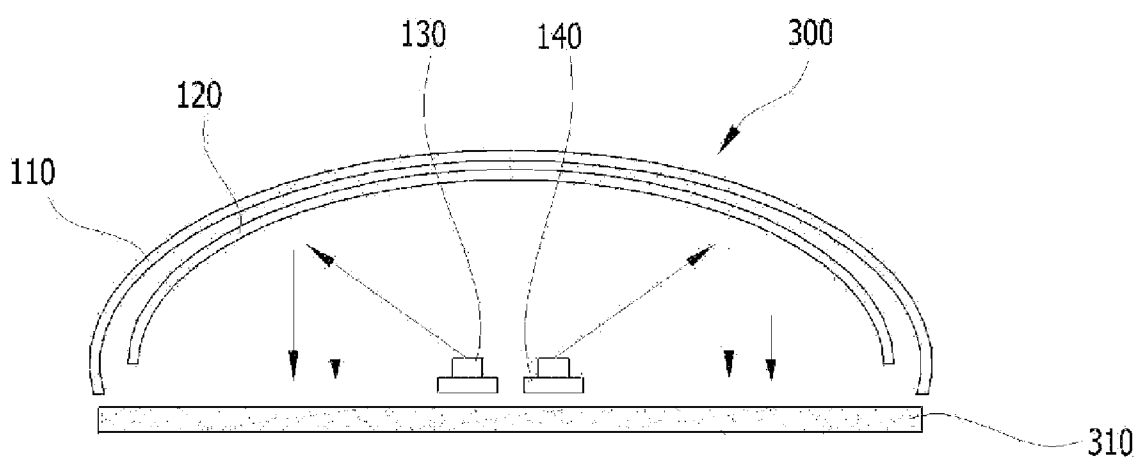


FIG. 1

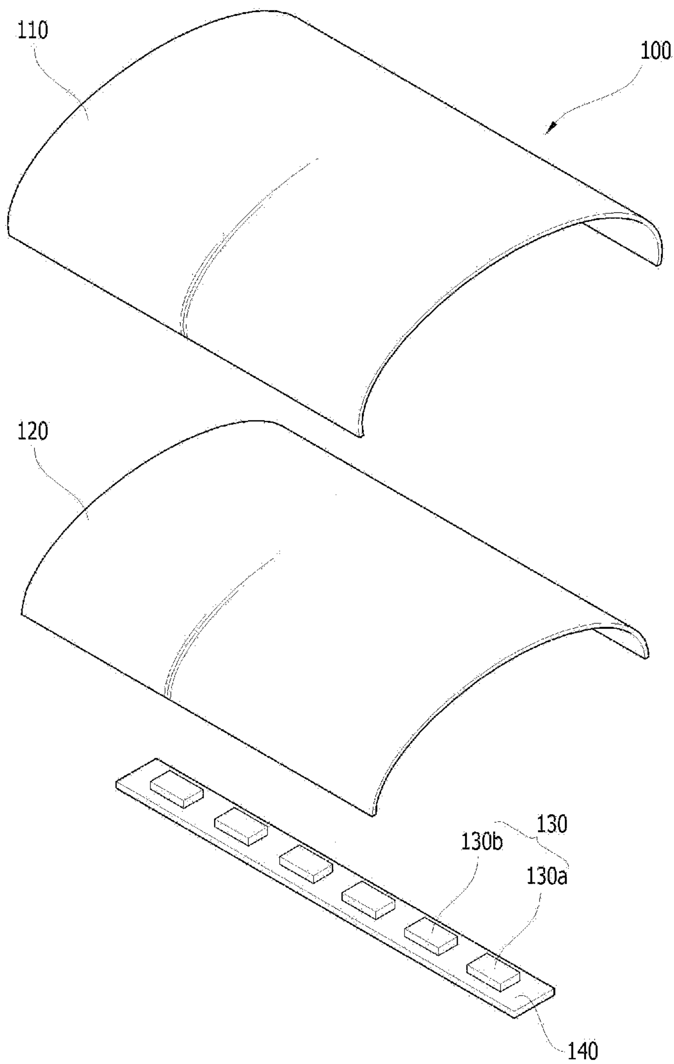


FIG. 2

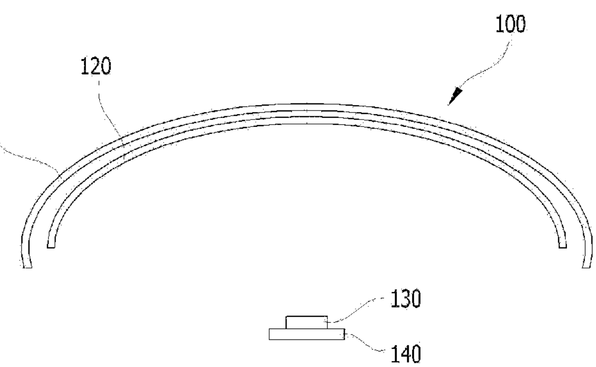


FIG. 3

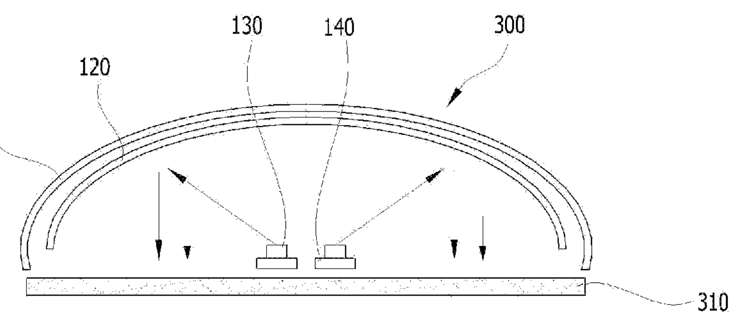


FIG. 4

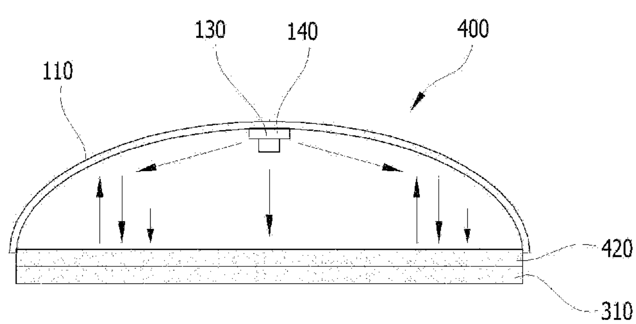


FIG. 5

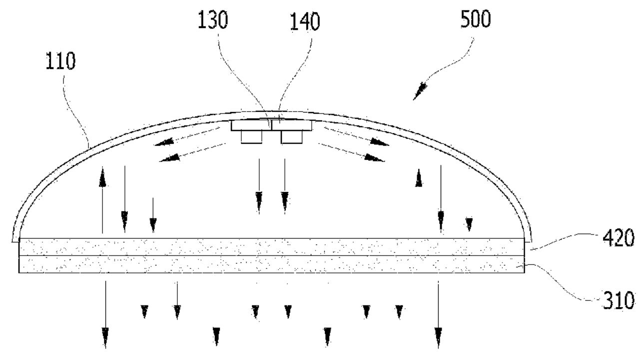


FIG. 6

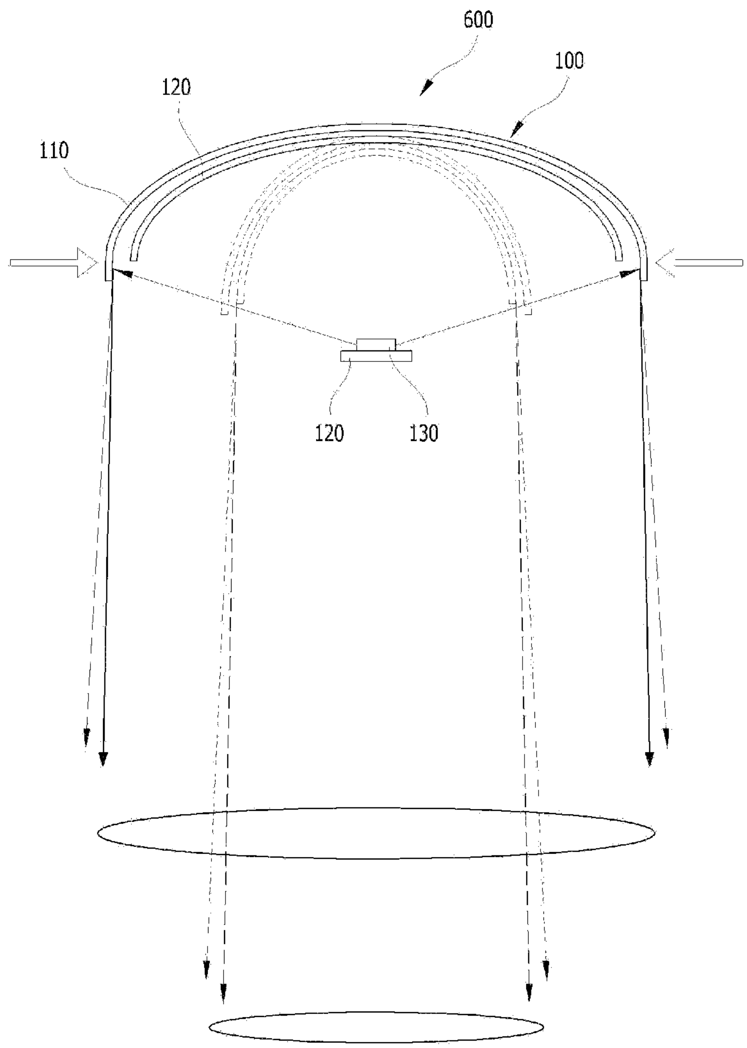


FIG. 7

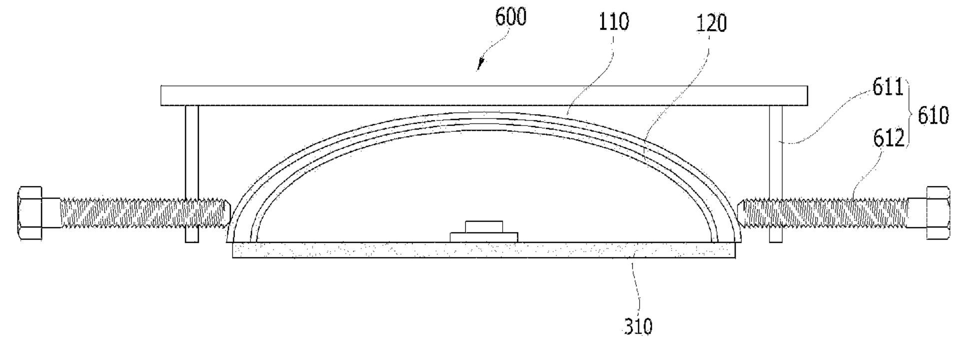

600
110
120
611
610
612
310

FIG. 8

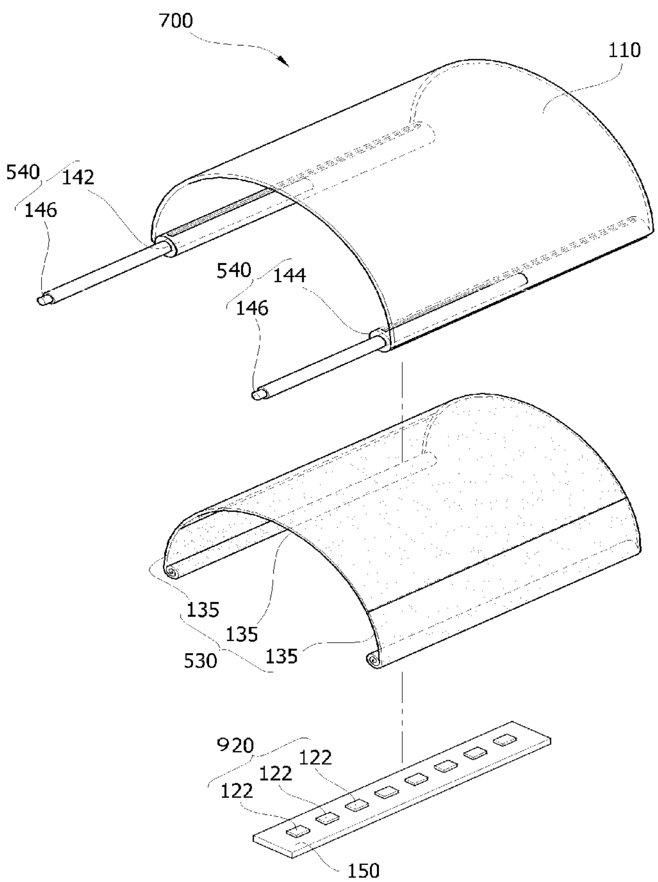

700
110
540
142
146
540
144
146
135
135
530
135
920
122
122
122
150

FIG. 9

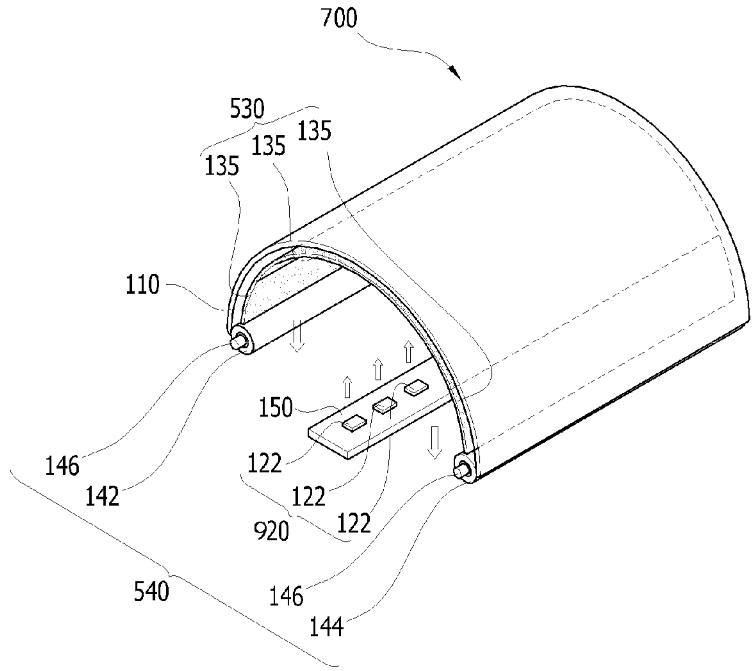

700
530
135
135
135
135
110
150
146
142
122
122
122
920
540
146
144

FIG. 10

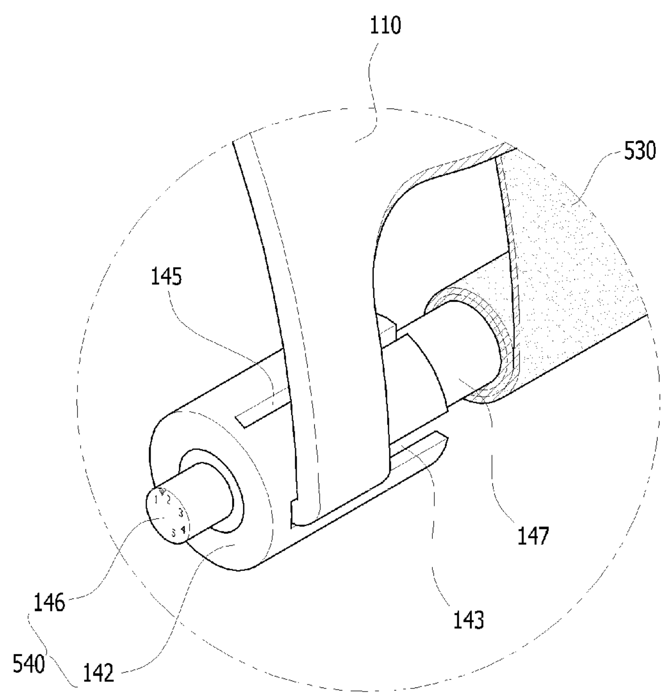

110
530
145
147
146
143
540
142

FIG. 11

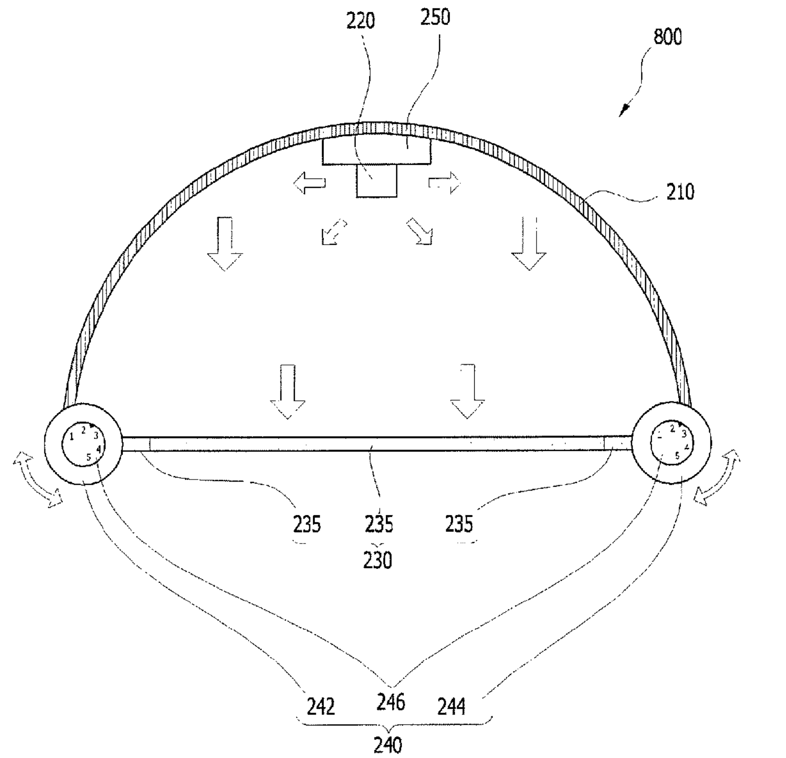

220
250
800
210
1
2
3
4
5
235
235
235
230
242
246
244
240

FIG. 12

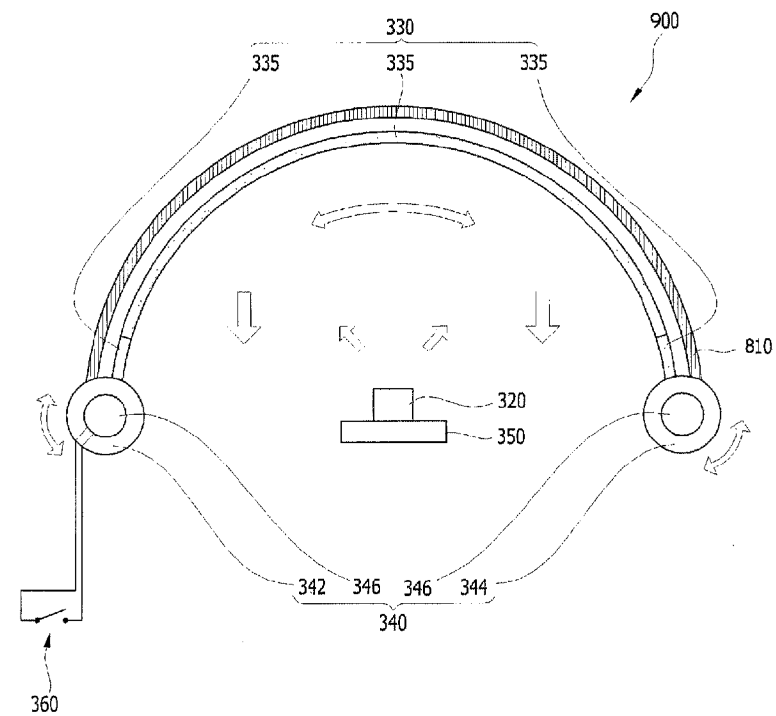
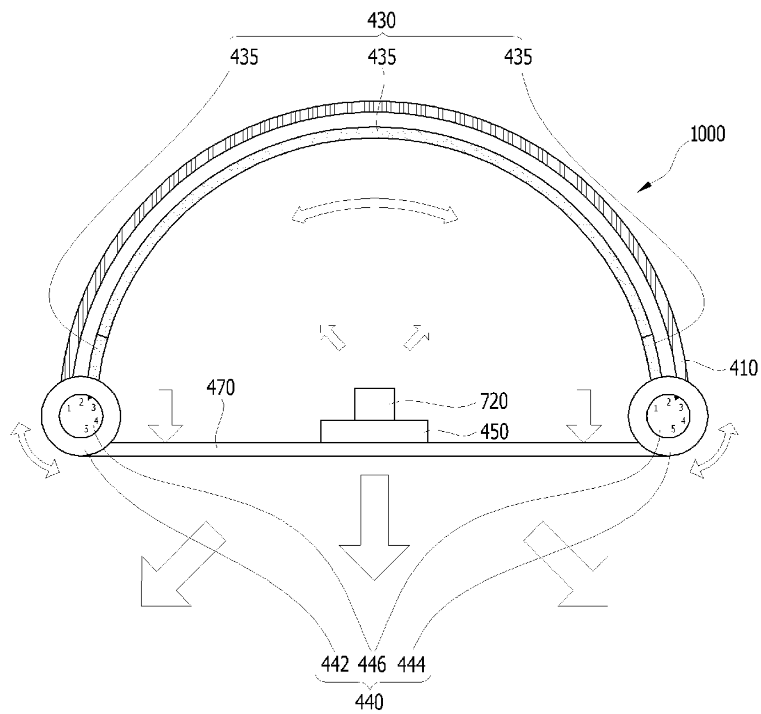

330
335
335
335
900
810
320
350
342
346
346
344
340
360

FIG. 13



LIGHTING APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority from and the benefit of Korean Patent Application No. 2008-58526, filed on Jun. 20, 2008 and Korean Patent Application No. 2008-62668, filed on Jun. 30, 2008, which are both hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Exemplary embodiments of the present invention relate to a lighting apparatus and, more particularly, to a lighting apparatus without color temperature change, which is capable of adjusting a width and a color of light.

2. Discussion of the Background

In general, a light-emitting diode (LED) has qualities such as high efficiency, long lifespan, low power consumption, environmentally-friendly, etc., as a light source. Therefore, the LED is widely used in various industrial fields.

A conventional LED lighting apparatus emits white light by mixing red light generated by a red LED, green light generated by a green LED, and blue light generated by a blue LED. Alternatively a conventional LED lighting apparatus emits white light by a white LED employing a blue LED chip and yellow fluorescent substance converting a portion of blue light generated by the blue LED into yellow light to mix the yellow light with a remaining blue light in order to generate white light. In the conventional LED lighting apparatus, the LED lighting apparatus employing a blue LED chip and yellow fluorescent substance occupies a major area.

In general, an LED emits heat, so that the fluorescent substance in the LED may be damaged by the heat. Therefore, when the LED is used for a long period of time, the fluorescent substance in the LED may become discolored, resulting in the desired white light to be changed into another colored light. Furthermore, when a lighting apparatus employing this type of LED is equipped in a confined space, the change in white color or discoloration may have serious effects.

SUMMARY OF THE INVENTION

Exemplary embodiments of the present invention provide a lighting apparatus without color temperature change.

Exemplary embodiments of the present invention also provide a lighting apparatus capable of adjusting color required by a user.

Additional features of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention.

An exemplary embodiment of the present invention discloses a lighting apparatus, with a light reflector having a concave surface; a light emitting diode (LED) disposed under the concave surface of the light reflector to provide the concave surface with light; and a light-changing film to convert a first light generated by the LED into a second light.

An exemplary embodiment of the present invention also discloses a lighting apparatus with a light reflector having a concave surface; a light-generating part disposed under the concave surface of the light reflector to provide the light reflector with light; and an illumination width adjusting part to adjust a width of the light reflector by compressing side portions of the light reflector.

An exemplary embodiment of the present invention also discloses a lighting apparatus with a light reflector; a light emitting diode (LED) part disposed under the light reflector, the LED part comprising at least one LED; a fluorescent film having first to n-th fluorescent substance parts, each of the first to n-th fluorescent substance parts to convert light generated by the LED into light with at least one different color; and a driving part to select one of the first to n-th fluorescent substance parts.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention, and together with the description serve to explain the principles of the invention.

FIG. **1** is an exploded perspective view illustrating a lighting apparatus according to an exemplary embodiment of the present invention.

FIG. **2** is a cross-sectional view of the lighting apparatus in FIG. **1**.

FIG. **3** is a cross-sectional view illustrating a lighting apparatus according to another exemplary embodiment of the present invention.

FIG. **4** is a cross-sectional view illustrating a lighting apparatus according to still another exemplary embodiment of the present invention.

FIG. **5** is a cross-sectional view illustrating a lighting apparatus according to still another exemplary embodiment of the present invention.

FIG. **6** is a conceptual view illustrating a lighting apparatus according to still another exemplary embodiment of the present invention.

FIG. **7** is a cross-sectional view of the lighting apparatus in FIG. **6**.

FIG. **8** is an exploded perspective view illustrating a lighting apparatus according to still another exemplary embodiment of the present invention.

FIG. **9** is a perspective view illustrating the constructed lighting apparatus in FIG. **8**.

FIG. **10** is a partially cut-out perspective view illustrating a driving part in FIG. **8**.

FIG. **11** is a cross-sectional view illustrating a lighting apparatus according to still another exemplary embodiment of the present invention.

FIG. **12** is a cross-sectional view illustrating a lighting apparatus according to still another exemplary embodiment of the present invention.

FIG. **13** is a cross-sectional view illustrating a lighting apparatus according to still another exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The invention is described more fully hereinafter with reference to the accompanying drawings, in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure is thorough, and will fully convey the scope of the invention to those skilled in the art. In the drawings, the size and relative sizes of layers and regions may be exaggerated for clarity. Like reference numerals in the drawings denote like elements.

It will be understood that when an element or layer is referred to as being "on" or "connected to" another element or layer, it can be directly on or directly connected to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on" or "directly connected to" another element or layer, there are no intervening elements or layers present.

FIG. **1** is an exploded perspective view illustrating a lighting apparatus according to an exemplary embodiment of the present invention, and FIG. **2** is a cross-sectional view of the lighting apparatus in FIG. **1**.

Referring to FIG. **1** and FIG. **2**, a lighting apparatus **100** according to an exemplary embodiment of the present invention includes a light reflector **110**, a fluorescent film **120** and at least one light emitting diode (LED) **130**.

The light reflector **110** has, for example, an arch-shaped cross-section and is extended along a first direction. A concave surface of the light reflector **110** is a light-reflecting surface. The fluorescent film **120** may include, for example polymer. The fluorescent film **120** is disposed under the light reflector **110** to cover the concave surface of the light reflector **110**.

The LEDs **130** are mounted on a printed circuit board (PCB) **140** in a line along the first direction. The LEDs **130** are spaced apart from each other. The LEDs **130** are disposed such that a first surface of the LEDs **130**, through which light is emitted, faces the fluorescent film **120** and light reflector **110**.

For example, a blue LED or an ultraviolet light (UV) LED may be employed as the LED **130**. In this case, the fluorescent film **120** may include, for example, an optically transparent polymer, and fluorescent substance distributed in the optically transparent polymer to generate white light. Examples of the fluorescent substance include YAG fluorescent substance, barium-silicate based or strontium-gallium sulfide based green fluorescent substance or aluminum-terbium based yellow fluorescent substance.

Therefore, blue light or UV light generated by the LED **130** is changed by the fluorescent material of the fluorescent film **120**. The light passing through the fluorescent film **120** is reflected by the light reflector **110** and repasses through the fluorescent film **120** to generate, for example white light.

Alternatively, the LEDs **130** may include blue LEDs **130*a*** and red LEDs **130*b*** alternately disposed with each other. In this case, color rendering property may be enhanced.

According to the lighting apparatus **100** described above, the LED **130** and the fluorescent film **120** converting the light generated by the LED **130** are spaced apart from each other, so that heat generated by the LED **130** is not transmitted to the fluorescent film **120**. This prevents the fluorescent film **120** from being discolored and helps in maintaining a consistent color of the light.

The LED **130** has a first surface through which light is emitted and a second surface opposite to the first surface. In general, more heat is irradiated through the second surface of the LED **130** than the first surface. According to the lighting apparatus **100**, the first surface of the LED **130** faces the fluorescent film **120**, so that the second surface of the LED **130** faces an opposite direction of the fluorescent film **120**. Therefore, radiant heat generated by the LED **130** is prevented from being transmitted to the fluorescent film **120**.

As a result, discoloration of the fluorescent film **120** is prevented to maintain white light of the lighting apparatus **100**, even when used extended periods of time.

Although not shown in FIG. **1** and FIG. **2**, the fluorescent film **120** may be disposed under the LED **130**. Furthermore, the fluorescent film **120** may be disposed such that the fluorescent film **120** makes contact with the PCB **140** on which the LED **130** is mounted. In this case, a portion of the fluorescent film **120**, which makes contact with the LED **130**, may be discolored by the heat. However, the fluorescent film **120** has a relative low thermal conductivity, so that only the portion in which no light passes through is discolored. As a result, the object of the present invention may be achieved.

FIG. **3** is a cross-sectional view illustrating a lighting apparatus according to another exemplary embodiment of the present invention.

The lighting apparatus **300** in FIG. **3** is substantially the same as the lighting apparatus **100** in FIG. **1** and FIG. **2**, except for an arrangement of the LEDs **130**. Thus, same reference numbers will be used for the same elements and any further explanation will be omitted.

Referring to FIG. **3**, the lighting apparatus **300** according to the present exemplary embodiment includes a light reflector **110**, a fluorescent film **120** and an LED **130**. The lighting apparatus **300** may further include a light-diffusing plate **310** to improve brightness uniformity by diffusing light generated by the LED **130**.

Two lines of the LEDs **130** are disposed on two PCBs **140**, respectively, along a first direction that is in the same longitudinal direction as the light reflector **110**. Not shown in FIG. **3**, the LEDs **130** may be arranged in two lines on one PCB **140** and the LEDs **130** may be disposed in more than two lines along the first direction. For example, the PCB **140** may be disposed directly on the light-diffusing plate **310**.

The LEDs **130** may include blue LEDs or UV LEDs and red LEDs alternately disposed with each other. Furthermore, a first line of blue LEDs and a second line of blue LEDs may be disposed alternately to form a zigzag shape to improve brightness uniformity.

The LEDs **130** are disposed such that the LEDs **130** are spaced apart from the fluorescent film **120** and the first surface of the LED **130** faces the fluorescent film **120** and light reflector **110**. Therefore, the second surface of the LEDs **130** faces opposite direction of the fluorescent film **120**, so that radiant heat generated by the LED **130** is prevented from being transmitted to the fluorescent film **120**.

As a result, discoloration of the fluorescent film is prevented to maintain initial color, and luminance is enhanced by increasing the number of LEDs **130**.

Not shown in FIG. **3**, the fluorescent film **120** may be disposed under the PCB **140**. In detail, the fluorescent film **120** may be disposed on an upper or lower surface of the light-diffusing plate **310**. In this case, a portion of the fluorescent film **120**, which is adjacent to the LED **130**, may be discolored by heat. However, the fluorescent film **120** has a relative low thermal conductivity, so that only the portion in which no light passes through is discolored. As a result, the object of the present invention may be achieved.

FIG. **4** is a cross-sectional view illustrating a lighting apparatus according to still another exemplary embodiment of the present invention.

Referring to FIG. **4**, a lighting apparatus **400** according to the present exemplary embodiment includes a light reflector **110**, a fluorescent film **420** and an LED **130**. The lighting apparatus **400** may further include a light-diffusing plate **310** to improve brightness uniformity by diffusing light generated by the LED **130**.

The light reflector **110** has an arch-shaped cross-section and is extended along a first direction. A concave surface of the light reflector **110** corresponds to a light-reflecting surface.

The PCB **140**, on which the LEDs **130** are mounted, is disposed on the concave surface of the light reflector **110**. For example, the PCB **140** is disposed at a center portion of the light reflector **110** along the first direction. The first surface of the LED **130**, through which light is emitted, faces the fluorescent film **420**, and the second surface of the LED **130**, which is opposite to the first surface, is attached to the light-reflecting surface of the light reflector **110**.

The fluorescent film **420** may be disposed under the light reflector **110** to have a chord shape connecting end portions of the light reflector **110**. The fluorescent film **420** may be disposed on an upper surface or a lower surface of the light-diffusing plate **110**. The light-diffusing plate **310** and the fluorescent film **420** may be integrally formed with each other by dispersing fluorescent material into the light-diffusing plate **310**.

For example, a blue LED or an ultraviolet light (UV) LED may be employed as the LED **130**. In this case, the fluorescent film **420** may include, for example, an optically transparent polymer, and fluorescent substance distributed in the optically transparent polymer to generate white light. Examples of the fluorescent substance include YAG fluorescent substance, barium-silicate based or strontium-gallium sulfide based green fluorescent substance or aluminum-terbium based yellow fluorescent substance.

Therefore, blue light or UV light generated by the LED **130** is changed by the fluorescent material of the fluorescent film **420**. The light generated by the LED **130** passes through the fluorescent film **420** to generate, for example white light.

Alternatively, the LEDs **130** may include blue LEDs **130***a* and red LEDs **130***b* alternately disposed with each other. In this case, color rendering property may be enhanced.

According to the lighting apparatus **400** described above, the LED **130** and the fluorescent film **420** converting the light generated by the LED **130** are spaced apart from each other, so that heat generated by the LED **130** is not transmitted to the fluorescent film **420**.

Therefore, the fluorescent film **420** is prevented from being discolored to maintain color temperature of light.

The LED **130** has a first surface through which light is emitted and a second surface opposite to the first surface. In general, more heat is irradiated through the second surface of the LED **130** than the first surface. According to the lighting apparatus **400**, the first surface of the LED **130** faces the fluorescent film **420**, so that the second surface of the LED **130** faces an opposite direction of the fluorescent film **420**. Therefore, radiant heat generated by the LED **130** is prevented from being transmitted to the fluorescent film **420**.

As a result, discoloration of the fluorescent film **420** is prevented to maintain white light of the lighting apparatus **400**.

Furthermore, the lighting apparatus **400** in FIG. **4** is a direct lighting type whereas the lighting apparatus **100** in FIG. **1** and FIG. **2** and the lighting apparatus **300** in FIG. **3** is an indirect lighting type, so that the lighting apparatus **400** may have improved luminance.

FIG. **5** is a cross-sectional view illustrating a lighting apparatus according to still another exemplary embodiment of the present invention.

The lighting apparatus **500** in FIG. **5** is substantially the same as the lighting apparatus **400** in FIG. **4**, except for an arrangement of the LEDs **130**. Thus, same reference numbers will be used for the same elements and any further explanation will be omitted.

Referring to FIG. **5**, the lighting apparatus **500** according to the present exemplary embodiment includes a light reflector **110**, a fluorescent film **420** and an LED **130**. The lighting apparatus **500** may further include a light-diffusing plate **310** to improve brightness uniformity by diffusing light generated by the LED **130**.

Two lines of the LEDs **130** are disposed on two PCBs **140**, respectively, along a first direction that is longitudinal direction of the light reflector **110**. The two PCBs **140**, on which the LEDs **130** are mounted, are disposed on a center portion of a concave surface of the light reflector **110** having an arch-shaped cross-section along the first direction. The first surface of the LED **130**, through which light is emitted, faces a lower portion, and the second surface that is opposite to the first surface may be attached to a light-reflecting surface of light reflector **110**. Not shown in FIG. **5**, the LEDs **130** may be arranged in two lines on one PCB **140** and the LEDs **130** may be disposed in more than two lines along the first direction.

The LEDs **130** may include blue LEDs or UV LEDs and red LEDs alternately disposed with each other. Furthermore, a first line of blue LEDs and a second line of blue LEDs may be disposed alternately to form a zigzag shape to improve brightness uniformity.

The LEDs **130** are disposed such that the LEDs **130** are spaced apart from the fluorescent film **420** and the first surface of the LED **130** faces the fluorescent film **420**. Therefore, the second surface of the LEDs **130** faces opposite direction of the fluorescent film **420**, so that radiant heat generated by the LED **130** is prevented from being transmitted to the fluorescent film **420**.

As a result, discoloration of the fluorescent film is prevented to maintain initial color, and luminance is enhanced by increasing the number of LEDs **130**.

FIG. **6** is a conceptual view illustrating a lighting apparatus according to still another exemplary embodiment of the present invention, and FIG. **7** is a cross-sectional view illustrating the lighting apparatus embodying the conception of the lighting apparatus in FIG. **6**.

The lighting apparatus **600** in FIG. **7** is substantially the same as the lighting apparatus **100** in FIG. **1** and FIG. **2**, except for an illumination width adjusting part **610** and a light-diffusing plate **310**. Thus, same reference numbers will be used for the same elements and any further explanation will be omitted.

Referring to FIG. **6** and FIG. **7**, a lighting apparatus **600** according to the present exemplary embodiment includes a light reflector **110**, a fluorescent film **120**, an LED **130**, a light-diffusing plate **310** and an illumination width adjusting part **610**.

The light-diffusing plate **310** and fluorescent film **120** may include flexible materials.

The illumination width adjusting part **610** compresses side portions of the light reflector **110** to adjust width of the light reflector **110**, so that width of illumination may be adjusted. In order for that, the illumination width adjusting part **610** may include, for example a supporting part **611** and a screw **612**.

The supporting part **611** is disposed such that the supporting part **611** is adjacent to the side portions of the light reflector **110**. The screw **612** passes through the supporting part **611**. The screw **612** moves forward or backward to adjust the width of the light reflector **110** when the screw **612** rotates along a clock-wise direction or a counter clock-wise direction with respect to the supporting part **611**.

In order to automatically adjust the width of the light reflector **110**, the lighting apparatus **600** may further include a motor (not shown) connected to the screw **612** to rotate the screw **612** and a control part (not shown) controlling the motor.

In FIG. **6** and FIG. **7**, the illumination width adjusting part **610** is equipped to the lighting apparatus **100** in FIG. **1** and FIG. **2**. Although not shown in FIG. **3**, FIG. **4** and FIG. **5**, the illumination width adjusting part **610** may be equipped to the lighting apparatus **300**, **400** and **500** in FIG. **3**, FIG. **4** and FIG. **5**.

As described above, according to the present embodiment, a width of lighting area may be adjusted when required. That is, the lighting apparatus **600** may illuminate a relatively small area with relatively high brightness or a relatively large area with relatively low brightness.

Hereinbefore, the lighting apparatuses employ the fluorescent film as an example, but other kind of a light-changing film changing characteristics of light may be employed. That is, the present invention is useful to all kinds of polymer film that may be damaged by heat generated by the LED.

FIG. **8** is an exploded perspective view illustrating a lighting apparatus according to still another exemplary embodiment of the present invention, and FIG. **9** is a perspective view illustrating the constructed lighting apparatus in FIG. **8**.

Referring to FIGS. **8** and **9**, a lighting apparatus **700** according to the present embodiment includes a light reflector **110**, an LED part **920**, a fluorescent film **530** and a driving part **540**.

The light reflector **110** has an arch-shaped cross-section and is extended along longitudinal direction thereof.

The LED part **920** is disposed under the light reflector **110**, and has at least one LED **122**. The at least one LED **122** may be arranged in a line along a first direction on a PCB **150**. Alternatively, the LEDs **122** may be arranged in two lines along the first direction on the PCB **150**.

A blue LED or an UV LED may be employed as the LED **122**.

The fluorescent film **530** has first to n-th fluorescent substance parts **135**, each of which converts light generated by the LED into different colored light. The fluorescent film **530** may include, for example, poly ethylene terephtalate (PET) or polycarbonate (PC). The fluorescent film **530** may be disposed such that the fluorescent film **530** wraps the LEDs **122** disposed under the light reflector **110**. The fluorescent film **530** and the LED part **920** are spaced apart from each other to prevent the fluorescent film **530** from being discolored by heat generated by the LED part **920**.

Each of the first to n-th fluorescent substance parts **135** may include at least one of a red fluorescent substance and a green fluorescent substance, to generate red light, green light or white light. The red fluorescent substance may include barium-silicate based material, and the green fluorescent substance may include strontium sulfide based material.

The driving part **540** includes a selection part **146** for winding up the fluorescent film **530**, and one of the first to n-th fluorescent substance parts **135** may be selected through the driving part **540**. The driving part **540** may further include a first supporting part **142** and a second supporting part **144** formed at an end portion of the light reflector **110** to fix the light reflector **110**. The first supporting part **142** and the second supporting part **144** of the driving part **540** may be formed at first and second end portions of the light reflector **110**, respectively.

The lighting apparatus **700** described above uses the LED part **920** as a light source. A first light generated by the LED part **920** is converted into a second light through the fluorescent film **530**. Each of the fluorescent substance parts **135** of the fluorescent film **530** has different kind of or different amount of fluorescent substance, so that the second light may have various characteristics.

For example, when white light is required, a blue LED and red and green fluorescent substance may be used. In the present exemplary embodiment, the lighting apparatus **700** employs, for example, a blue LED as a light source. The first light generated by the blue LED is converted into white light by the fluorescent film **530**. The fluorescent film **530** may have the first to n-th fluorescent substance parts **135**, each of which has different ratio of red fluorescent substance to green fluorescent substance.

For example, the first fluorescent substance part **135** has 5% of red fluorescent substance and 95% of green fluorescent substance, the second fluorescent substance part **135** has 10% of red fluorescent substance and 90% of green fluorescent substance, . . . , and the n-th fluorescent substance part **135** has A % of red fluorescent substance and (100-A) % of green fluorescent substance.

When the ratio of red fluorescent substance to green fluorescent substance varies between the adjacent fluorescent substance parts **135**, a gradual color change may be obtained and various colored light such as cool white and warm white may be obtained.

When the selection part **146** is rotated along a first direction or a second direction, one of the first to n-th fluorescent substance parts **135** is selected.

Additionally, the fluorescent film **530** may further include an (n+1)-th fluorescent substance part **135** having no fluorescent substance. Therefore, when the (n+1)-th fluorescent substance part **135** is selected, blue light or UV light generated by the LED part **920** may be directly illuminated.

FIG. **10** is a partially cut-out perspective view illustrating a driving part in FIG. **8**. In FIG. **10**, the light reflector **110** and the second supporting part are illustrated in a state partially cut-out.

Referring to FIG. **10**, the driving part **540** may further include a first supporting part **142** and a second supporting part **144** connected to the light reflector **110**. The first supporting part **142** and the second supporting part **144** are disposed at first and second end portions of the light reflector **110**, respectively. The first supporting part **142** and the second supporting part **144** may have, for example, a cylindrical shape.

The first supporting part **142** and the second supporting part **144** have a first hole **143** formed on a surface thereof. The first hole **143** is extended along longitudinal direction of the first supporting part **142** and the second supporting part **144**. An end portion of the light reflector **110** is inserted into the first hole **143**, so that the first supporting part **142** and the second supporting part **144** are combined with the light reflector **110**. A rotation shaft **147** may be connected with the selection part **146**, and inserted into the first supporting part **142** and the second supporting part **144**.

The first supporting part **142** and the second supporting part **144** may further include a second hole **145** formed on a surface thereof. The second hole **145** may be parallel with the first hole **143**. The fluorescent film **530** penetrates the second hole **145** to be wound up by the rotation shaft **147**. Therefore, when the selection part **146** is rotated, the rotation shaft **147** is also rotated to wind up the fluorescent film **530**.

Even when the selection part **146** is rotated, the first supporting part **142** and the second supporting part **144** are stationary to fix the light reflector **110**.

When the first supporting part **142** and the second supporting part **144** are not extended along a longitudinal direction of the light reflector **110** as illustrated in FIG. **10**, the first supporting part **142** and the second supporting part **144** do not require the second hole **145**.

FIG. **11** is a cross-sectional view illustrating a lighting apparatus according to still another exemplary embodiment of the present invention. The lighting apparatus **800** in FIG. **11** is substantially the same as the lighting apparatus **700** in FIG. **8** and FIG. **9**, except for the position of the LED part **220**, a PCB **250** and a fluorescent film **230**. Thus, same reference numbers will be used for the same elements and any further explanation will be omitted.

Referring to FIG. **11**, the lighting apparatus **800** according to the present exemplary embodiment includes a light reflector **210**, an LED part **220**, a fluorescent film **230** and a driving part **240**. The LED part **220** of the lighting apparatus **800** may be disposed such that the second surface of the LED part **220**, which is opposite to the first surface emitting light, is adjacent to a concave surface of the light reflector **210**.

The light reflector **210** has an arch-shaped cross-section, and is extended along a first direction.

The LED part **220** is disposed under the light reflector **210**, and includes at least one LED. The LEDs may be mounted on the PCB **250** along the first direction. Alternatively, the LEDs may be arranged in two lines along the first direction on the PCB **250**.

A blue or UV LED may be employed as the LED of the LED part **220**.

The fluorescent film **230** includes first to n-th fluorescent substance parts **235** to generate different colored light by using blue or UV light generated by the LED part **220**. The fluorescent film **230** facing the first surface of the LED part **220** defines a chord between the first supporting part **242** and the second supporting part **244**, the chord corresponding to an arc defined by the light reflector **210**.

The driving part **240** includes a selection part **246** for winding up the fluorescent film **230**, and one of the first to n-th fluorescent substance parts **235** may be selected through the driving part **240**. The driving part **240** may further include the first supporting part and the second supporting part **244** formed at an end portion of the light reflector **210** to fix the light reflector **210**. The first supporting part **242** and the second supporting part **244** of the driving part **240** may be formed at first and second end portions of the light reflector **210**, respectively.

The first light generated by the LED part **220** is converted into the second light by the fluorescent film **230**. According to the lighting apparatus **800**, a user may select a color by rotating the selection part **246** for winding up the fluorescent film **230** as described in the previous embodiment in FIG. **8** and FIG. **9**. However, according to the present embodiment, the fluorescent film **230** is flat, whereas the fluorescent film **530** in FIG. **8** and FIG. **9** is curved, so that an operation time required for winding up may be reduced.

FIG. **12** is a cross-sectional view illustrating a lighting apparatus according to still another exemplary embodiment of the present invention. The lighting apparatus **900** in FIG. **12** is substantially the same as the lighting apparatus **700** in FIG. **8** and FIG. **9**, except for an electrical rotating part **360**. Thus, same reference numbers will be used for the same elements and any further explanation will be omitted.

Referring to FIG. **12**, the lighting apparatus **900** according to the present exemplary embodiment includes a light reflector **810**, an LED part **320**, a fluorescent film **330** and a driving part **340**. The lighting apparatus **900** may further include an electrical rotating part **360** electrically connected to the selection part **346** to rotate a rotation shaft for winding up the fluorescent film **330**.

The light reflector **810** has an arch-shaped cross-section and is extended along longitudinal direction thereof.

The LED part **320** is disposed under the light reflector **810**, and has at least one LED. The at least one LED may be arranged in a line along a first direction on a PCB **350**. Alternatively, the LEDs may be arranged in two lines along the first direction on the PCB **350**.

A blue LED or an UV LED may be employed as the LED.

The fluorescent film **330** has first to n-th fluorescent substance parts **335**, each of which converts light generated by the LED of the LED part **320** into different colored lights. The fluorescent film **330** may be disposed such that the fluorescent film **330** wraps the LEDs disposed under the light reflector **810**. The fluorescent film **330** and the LED part **320** are spaced apart from each other to prevent the fluorescent film **330** from being discolored by heat generated by the LED part **320**.

The driving part **340** includes a selection part **346** for winding up the fluorescent film **330**, and one of the first to n-th fluorescent substance parts **335** may be selected through the driving part **340**. The driving part **340** may further include a first supporting part **342** and a second supporting part **344** formed at an end portion of the light reflector **810** to fix the light reflector **810**. The first supporting part **342** and the second supporting part **344** of the driving part **340** may be formed at first and second end portions of the light reflector **810**, respectively.

The electrical rotating part **360** may include, for example, a toggle switch, or push switch. For example, when the electrical rotating part **360** is in a first state, the selection part **346** rotates along a clock-wise direction, or when the electrical rotating part **360** is in a second state, the selection part **346** rotates along a counter clock-wise direction to wind up the fluorescent film **330**. The electrical rotating part **360** may include, for example, two motors connected to a first rotation shaft (not shown) of the first supporting part **342** and a second rotation shaft (not shown) of the second supporting part **344**, respectively. When at least one of two motors operates, one of the first to n-th fluorescent substance parts **335** in the fluorescent film **330** may be selected.

According to the present embodiment, the electrical rotating part **360** may be easily operated to select one of the first to n-th fluorescent substance parts **335** of the fluorescent film **330**. Furthermore, the lighting apparatus **900** may be equipped at a position higher than a user's reach.

For example, the lighting apparatus **900** may be equipped at the ceiling of the room, and the electrical rotating part **360** may be equipped at a wall within a user's reach, so that color of the lighting apparatus **900** may be controlled easily.

FIG. **13** is a cross-sectional view illustrating a lighting apparatus according to still another exemplary embodiment of the present invention. The lighting apparatus **1000** in FIG. **13** is substantially the same as the lighting apparatus **700** in FIG. **8** and FIG. **9**, except for a light-diffusing plate **470**. Thus, same reference numbers will be used for the same elements and any further explanation will be omitted.

Referring to FIG. **13**, a lighting apparatus **1000** includes a light reflector **410**, an LED part **720**, a fluorescent film **430** and a driving part **440**. The lighting apparatus **1000** may further include a light-diffusing plate **470** disposed adjacent to a second surface of the LED part **720**, wherein the second surface of the LED part **720** faces an opposite direction of the fluorescent film **430** and a first surface of the LED part **720** is opposite to the second surface of the LED part **720**. The light-diffusing plate **470** diffuses light generated by the LED part **720** to improve brightness uniformity.

The light reflector **410** has an arch-shaped cross-section and extends along a longitudinal direction thereof.

The LED part **720** is disposed under the light reflector **410**, and has at least one LED. The at least one LED may be arranged in a line along a first direction on a PCB **450**. Alternatively, the LEDs may be arranged in two lines along the first direction on the PCB **450**.

A blue LED or an UV LED may be employed as the LED.

The fluorescent film **430** has first to n-th fluorescent substance parts **435**, each of which converts light generated by the LED into different colored lights. The fluorescent film **430** may be disposed such that the fluorescent film **430** wraps the LEDs disposed under the light reflector **410**. The fluorescent film **430** and the LED part **720** are spaced apart from each other to prevent the fluorescent film **430** from being discolored by heat generated by the LED part **720**.

The driving part **440** includes a selection part **446** for winding up the fluorescent film **430**, and one of the first to n-th fluorescent substance parts **435** may be selected through the driving part **440**. The driving part **440** may further include a first supporting part **442** and a second supporting part **444** formed at an end portion of the light reflector **410** to fix the light reflector **410**. The first supporting part **442** and the second supporting part **444** of the driving part **440** may be formed at first and second end portions of the light reflector **410**, respectively.

According to some exemplary embodiments of the present invention, a color of light illuminated by the lighting apparatus may be adjusted by using the fluorescent film having the first to n-th fluorescent substance parts, in detail, by rotating the selection part for selecting one of the first to n-th fluorescent substance parts of the fluorescent film.

Furthermore, the lighting apparatus having electrical rotating part connected to the selection part may be equipped at a position beyond a user's reach.

It will be apparent to those skilled in the art that various modifications and variation can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A lighting apparatus, comprising:
- a light emitting diode (LED);
- a light reflector having a convex outer surface, and a concave inner surface that is configured to reflect light emitted from the LED;
- an illumination width adjusting part to adjust the distance between first and second edges of the light reflector by compressing opposing side portions of the light reflector; and
- a light-changing film disposed directly on the inner surface of the light reflector and configured change the wavelength of the light emitted from the LED,
- wherein the light changing film is disposed between the inner surface of the light reflector and the LED, such that substantially all of the reflected light passes through the light changing film before being reflected, and
- wherein ends of the light changing film are spaced apart from the light reflector by an air gap, when the light reflector is not compressed by the illumination width adjusting part.

2. The lighting apparatus of claim **1**, wherein the light-changing film is a fluorescent film to increase the wavelength of the light.

3. The lighting apparatus of claim **2**, wherein the fluorescent film is spaced apart from the LED.

4. The lighting apparatus of claim **3**, wherein:
- the LED has an emitting surface to emit the light and an opposing non-emitting surface; and
- the LED is disposed such that the emitting surface faces the fluorescent film.

5. The lighting apparatus of claim **3**, wherein the lighting apparatus further comprises a plurality of the LEDs arranged in a row that extends parallel to the first and second edges of the light reflector.

6. The lighting apparatus of claim **5**, wherein the LEDs comprise at least two of a blue LED, a green LED, and a red LED, which are alternately disposed in the row.

7. The lighting apparatus of claim **5**, wherein the emitting surface of each LED faces the inner surface of the light reflector.

8. The lighting apparatus of claim **7**, wherein the fluorescent film is disposed between the light reflector and the LEDs.

9. The lighting apparatus of claim **8**, further comprising a light-diffusing plate to diffuse light reflected by the light reflector.

10. The lighting apparatus of claim **1**, wherein the illumination width adjusting part comprises:
- a supporting part disposed adjacent to the side portions of the light reflector; and
- a screw penetrating the supporting part and contacting one of the side portions of the light reflector, the screw configured to move forward or backward to adjust the distance between the first and second edges of the light reflector.

11. The lighting apparatus of claim **10**, wherein the illumination width adjusting part further comprises:
- a motor to rotate the screw; and
- a control part to control the motor.

12. The lighting apparatus of claim **1**, wherein:
- the light reflector has substantially linear opposing first and second edges; and
- the inner and outer surfaces extend from the first edge to the second edge.

13. A lighting apparatus, comprising:
- a light emitting diode (LED) part;
- a light reflector disposed over the LED part and having an inner surface configured to reflect light emitted from the LED part;
- a fluorescent film disposed to receive the light emitted from the LED part, portions of the fluorescent film comprising fluorescent substances, such that the portions each emit different colors of light; and
- a driving part to adjust the fluorescent film, such that different ones of the portions of the fluorescent film cover the inner surface of the light reflector and receive the light emitted by the LED part,
- wherein each portion is large enough to cover substantially all of the inner surface of the light reflector, and
- wherein the fluorescent film comprises a continuous film.

14. The lighting apparatus of claim **13**, wherein each of the portions of the fluorescent film comprises a red fluorescent substance, a green fluorescent substance, or a combination thereof.

15. The lighting apparatus of claim **14**, wherein portions of the fluorescent film that comprises both the red fluorescent substance and the green fluorescent substance each comprise different amounts of the red fluorescent substance and the green fluorescent substance.

16. The lighting apparatus of claim 13, wherein:
the LED part comprises a blue LED or an ultraviolet LED; and
a portion of the fluorescent film is transparent to light emitted by at least the blue LED or the ultraviolet LED.

17. The lighting apparatus of claim 13, wherein the driving part comprises:
a supporting part to fix the light reflector;
a rotation shaft connected to the fluorescent film; and
a selection part configured to select each portion of the fluorescent film by rotating the rotation shaft, such that the fluorescent film is wound onto and unwound from the rotation shaft, according to corresponding rotation directions of the rotation shaft.

18. The lighting apparatus of claim 17, wherein the driving part further comprises an electrical motor to rotate the rotation shaft.

19. The lighting apparatus of claim 13, wherein the fluorescent film and the LED part are spaced apart from each other.

20. The lighting apparatus of claim 19, wherein the LED part has an emitting surface from which the light is emitted and an opposing non-emitting surface, the emitting surface facing the inner surface of the light reflector.

21. The lighting apparatus of claim 19, wherein the LED part has an emitting surface from which the light is emitted and an opposing non-emitting surface, the non-emitting surface facing the inner surface of the light reflector.

22. The lighting apparatus of claim 13, wherein the driving part comprises:
a supporting part to fix the light reflector;
first and second rotation shafts respectively connected to opposing ends of the fluorescent film; and
a selection part configured to select each portion of fluorescent film by rotating the rotation shafts, such that the fluorescent film is wound around one of the first and second rotation shafts and unwound from the other of the first and second rotation shafts.

23. The lighting apparatus of claim 12, wherein the fluorescent film is spaced apart from the inner surface of the light reflector.

* * * * *